

Automated correction method of artifacts on heart rate time series

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1. Introduction

The Electrocardiogram (ECG) in ambulatory monitoring poses great interest in diagnostic, but the movement of the patient causes loss of information due to the occurrence of artifacts. The most sophisticated detection algorithms of fiducial points on the ECG fail when artifacts are present in heart rate (RR) time series (Task Force 1996). This causes the time indicator standard deviation from normal-to-normal interval (SDNN) in heart rate variability (HRV) to be robustless to artifacts. The manual correction is a close-at-hand solution but it is very tedious and subject to errors. García-González *et al.*, presented a robust indicator (SDNN10) obtained by automatic correction method (SDNN10 is the SDNN, computed after the suppression of the 10% of both histogram's tails). However, SDNN10 does not tackle asymmetries in the histogram.

Here it is proposed an automated method based on the elimination of the artifacts of the histogram in RR time series. However, its morphology is preserved, so that this standard indicator can still be used in HRV time analysis in presence of artifacts.

2. Materials and methods

The proposed method (pM) is based on the exclusion of the points on the RR histogram below to X_L and above to X_H (figure 1). These points are obtained by means of an algorithm based on the calculation of the areas S_L and S_H of the triangles, with two fixed vertices (x_{max} , x_{ref}) and a variable ones (x_i). x_L and x_H correspond with the points where S_L and S_H are maximum, respectively.

The effectiveness of the proposed method has been evaluated in artificial and real time series. The methodology is the following: In the original RR time series (artificial or real) artifacts are added, either false positive (FP) or false negative (FN) or both. These two types of artifacts simulates the impulsive noise, in the RR time series, due to the failure of the R-wave detection algorithm in ECG signal when the patient is in ambulatory

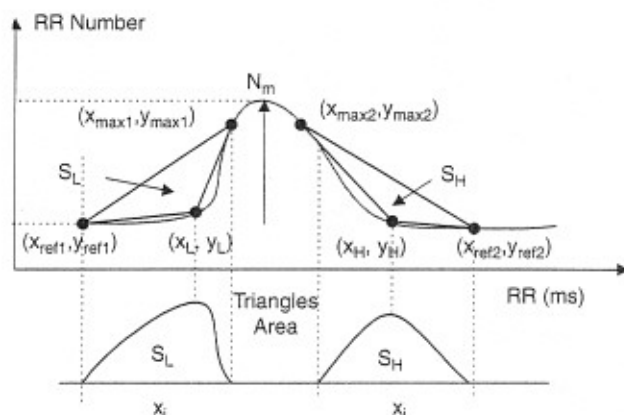


Figure 1. Method for eliminating artifacts from the histogram by computing the area of a triangle

monitoring conditions. The artifacts are added such that a certain asymmetry is always caused in the histogram. Further on, the artifacts are corrected with the pM. For the original series without artifacts, the standard indicator SDNN is calculated, giving robustless results. Additional, for the series with artifacts, the indicator SDNN10 is calculated and proves to be robust to artifacts. For the RR time series with artifacts, SDNN has not been considered (although calculated), because of its high sensibility to the artifacts (—) it has only been verified that indeed it is sensitive to artifact presence. Finally, to compare the behavior of SDNN in the original series without artifacts and in the series with the corrected data, the relative error is determined for each indicator (as percentage).

3. Results and discussion

The mean error observed in the SDNN (after correction) gives is 1,28%, while SDNN10 gives 14,68% for the same calculated value. These results show that the automatic correction method of artifacts gives values of SDNN that are very close to its original values without artifacts. The advantage of the pM is that it takes into account the

morphology of the histogram and eliminates the artifacts in both tails of histogram without losing the contiguous, useful information to the artifacts.

4. Conclusion

The obtained results show that the proposed automatic correction on the histogram (before the computation of standard indicators), guarantees good accuracy when the RR time series contains artifacts.

References

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